The Volatility and the Thermal Storage Performance of Binary Polyalcohols Systems Used in the Wall

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Abstract: In this paper, the volatility of binary Systems, consisting of neopentylglycol(NPG), pentaerythritol(PE) and trihytdroxy methyl-aminomethane(TAM) with different components, was studied experimentally. In the solid –solid phase change process, the weightless rates of binary polyalcohols systems are lower and less than 5 percent, and the weightless rates are zero if binary polyalcohols systems are sealed. In the solid –liquid phase change process, the weightless rates of binary polyalcohols systems are larger, and the weightless rates of binary systems are smaller if polyalcohols are sealed. The higher the temperature of polyalcohols is, the higher the volatility. Polyalcohols should be sealed in the process of thermal storage. The phase change temperatures and phase change heats of binary systems were studied experimentally by differential scaning calorimeter(DSC). The feasibility of the binary polyalcohols system used in the building envelope was analyzed. Results can provide the basis for the application of solid-solid phase change materials to the building field.

Key words: binary polyalcohols system; phase change temperature; phase change heat; volatility; weightless rate

1. INTRODUCTION

Energy storage of phase change materials has become important in the fields of new energy application and energy-saving technology. Especially in the building fields, the application of thermal storage of phase change materials has been focus at home and abroad[1]−[4]. It can save cooling load in the summer and heating load in the winter to add phase change materials into architectural materials by different methods. Phase change material building envelope can store cool or heat at night to bear part or all peak load in the daytime owing to the thermal property of phase change material, and decrease the indoor temperature fluctuation and raise the comfort degree.

Phase change materials include solid-liquid phase change materials and solid-solid phase change materials. Solid-liquid phase change materials such as paraffin are traditional phase change materials used in the field of thermal storage. However, they must be loaded by the containers if they are used in the building so not as to leak. In order to avoid this phenomenon, shape-stabilized phase-change materials are used. Shape-stabilized phase-change material is made up of supporting material and phase change material[5]-[7].

Solid-solid phase change materials have some advantages such as small change in volume, leaklessness, no phase separation. Solid-solid phase change materials have higher phase change temperature in general, so they are suitable to thermal storage at the middle or high temperature. Mixing two or several kinds of polyalcohols to form alloy can decrease their phase change temperature, thus they can be used in the lower temperature[8]-[10]. Polyalcohols are more ideal phase change materials used in the building envelope if phase change temperature is suitable. However, it should be considered that polyalcohols have volatility in the phase change process.

Phase change temperature and latent heat, stability and feasibility of phase change materials should be considered when choosing materials used in the building envelope. It is suitable that phase change temperature is between 20 and 40 centigrade according to different use[11].

In this paper, the volatility and thermal storage performance of polyalcohols mixture consisting of NPG, PE and TAM were studied. Polyalcohols mixtures used in the building envelope were chosen by testing phase change temperature and heat.

2. EXPERIMENTAL EQUIPMENT AND MATERIALS

Experimental equipment includes differential scanning calorimeter, analytic balance, beaker, heating furnace, infrared light, muller and so on. Differential scanning calorimeter was made in German Ntscz company, and its type is 200PC. The equipment is cooled by liquid nitrogen. Protective gas and purge gas are nitrogen with high purity degree. The velocities of flow of protective gas and purge gas are 65ml/min and 15 ml/min respectively.

Experimental materials are neopentylglycol, pentaerythritol, trihytdroxy methyl-aminomethane and alcohol made in Beijing reagent company

3. PREPARATION OF EXPERIMENTAL SAMPLES

Mix three kinds of polyalcohols by different mass proportion to form binary systems NPG/TAM, PE/NPG and TAM/PE. Fifteen samples were prepared in the experiment. They are shown in Table 1.

Tab.1: Numbers and composition of samples

Sample number	Composition
1	90％NPG+10%PE
2	70％NPG+30%PE
3	50％NPG+50%PE
4	30％NPG+70%PE
5	10％NPG+90%PE
6	90％NPG+10%TAM
7	70％NPG+30%TAM
8	50％NPG+50%TAM
9	30％NPG+70%TAM
10	10％NPG+90%TAM
11	90TAM+10%PE
12	70%TAM+30%PE
13	50TAM+50%PE
14	30TAM+70%PE
15	10TAM+90%PE

Preparation of mixture includes two methods. The first method is to mull and mix evenly sample, and heat it up to liquid in the electrical furnace, and then cool it in the air to solidify. The second method is to dissolve sample in the water or alcohol, and then heat it by infrared light, and remove infrared light after water or alcohol evaporate.

The first method is not suitable to preparing polyalcohols mixtures because three kinds of polyalcohols have different volatility. If the first method is used, the mass proportion of mixtures changes when heating and melting.In the experiment, we used the second method to make samples. Alcohol is used as dissolvent. The mass of sample has no weightlessness in the preparation.

4.EXPERIMENTAL METHODS

The volatility of nine samples was tested in the experiment. Every sample includes two kinds: one is sealed, and another is unsealed. Take a few of every sample, and put into aluminous crucible to prepare. At first, the initial weight of the sample was record, and then put sample into the electrical furnace to heat. The temperature of sample keeps constant for thirty minutes when its temperature gets the solid-solid phase change temperature, and then sample was weighed again. Sample was put into electrical furnace and heated sequentially to its melting point, and then weighed.

The phase change temperature and heat of fifteen samples were tested by DSC one by one.

5. RESULTS AND ANALYSIS

5.1 The Volatility of Polyalcohols Systems

The experimental results of the volatility of polyalcohols systems were shown in table 2 to 4. From the table, we can see that the weightless rates of binary systems are less than five percent in the solid-solid phase change. The weightless rates of binary systems in the solid-solid phase change are much less than that in the solid-liquid phase change. The volatility of binary system PE/NPG is the strongest. Polyalcohols binary systems had no weightless in the solid-solid phase change if polyalcohols were sealed.

The volatility of polyalcohols is related with the temperature. The higher the temperature is, the larger the volatility. Therefore it is suitable that polyalcohols are used in the lower temperature fields. Now polyalcohols has been valued by people. However, the volatility of polyalcohols should not be ignored in the application. Sealed methods should be used in the application to avoid the weightlessness.

5.2 Thermal Storage Performance of Binary Polyalcohols Systems

The testing results of binary systems were shown in the figure 1 to 4.

The phase change temperatures of binary system NPG/PE and TAM/NPG are much lower than that of single polyalcohols material. The difference of phase change temperatures of the two binary systems is small. The phase change temperatures of binary systems are all between 30 and 40 centigrade and have no relationship with the phase change temperatures of PE and TAM. The phase change temperatures of binary systems NPG/PE and TAM/NPG decrease to 41.1 and 39.7 centigrade respectively when the contents of NPG are up to 10 percent. The change in phase change temperature is not evident as the contents of NPG increase. The phase change temperatures of binary systems NPG/PE and TAM/NPG are 33.2 and 34 centigrade respectively when the contents of NPG are up to 90 percent. In general, the bigger the contents of NPG are, the lower the phase change temperatures of binary systems.

The phase change heat of binary system NPG/PE and TAM/NPG are much lower than that of single polyalcohols material. The difference of phase change heats of the two binary systems is small. The phase change heats decrease rapidly when adding a little NPG into PE or TAM. But the phase change heat increases gradually with the increasing of the contents of NPG.

Tab.2 The experimental results of binary system NPG/PE

Composition		90%NPG 10%PE	50%NPG 50%PE	10%NPG 90%PE
Solid-solid phase change temperature (℃)		33.2	33.9	41.1
Unsealed	Initial weight(mg)	9.2	7.3	12.6
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	8.8 /4.3	7.0 /4.1	12.0 /4.8
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	3.9 /57.6	3.9 /46.6	6.9/45.2
sealed	Initial weight(mg)	10.1	8.8	11.7
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	10.1/0	8.8/0	11.7/0
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	9.9/2	8.7/1.1	11.5/1.7

Tab 3 The experimental results of binary system NPG/TAM

Composition		90%NPG 10%TAM	50%NPG 50%TAM	10%NPG 90%TAM
Solid-solid phase change temperature (℃)		34	38.3	39.7
Unsealed	Initial weight(mg)	17.2	12.4	10.9
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	17.0/1.2	12.1/2.4	10.6/2.8
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	10.4/40	8.5/31.5	9.3/14.7
sealed	Initial weight(mg)	16.9	14.1	12.6
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	16.9/0	14.1/0	12.6/0
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	16.7/1.2	14.0/0.7	12.6/0

Tab.4 The experimental results of binary system TAM/PE

Composition		90%TAM 10%PE	50%TAM 50%PE	10%TAM 90%PE
Solid-solid phase change temperature (℃)		134	133.4	120.1
Unsealed	Initial weight(mg)	15.4	20.4	17.9
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	15.3/0.65	20.2/0.98	17.6/1.7
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	12.6/18.2	12.7/37.7	8.8/50.8
sealed	Initial weight(mg)	16.0	18.9	17.1
	Weight after solid-solid phase change(mg)/ Weightless rate (%)	16.0/0	18.9/0	17.1/0
	Weight after solid-liquid phase change(mg)/ Weightless rate (%)	16.0/0	18.8/0.5	17.0/0.6

The phase change temperature of binary system PE/TAM is higher, and about 130℃. The phase change temperature of the binary system consisting of PE and TAM decreases very small. The phase change heat of binary system PE/TAM is much lower than that of single polyalcohols material. The phase change temperature of PE/TAM has no evident changes and the phase change heat is lower, so this binary system has no value in the thermal storage fields.

The phase change temperature of binary systems with a certain constitution can change in the wider range. They are suitable to thermal storage in the building. The phase change temperatures of binary system NPG/PE and TAM/NPG are between 30 centigrade and 41 centigrade. The phase change heat of binary system is bigger when the content of NPG is 50 to 90 percent, and they can be used as thermal storage material.

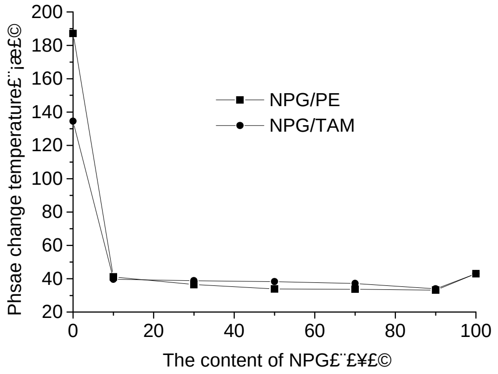

Fig. 1 The relationship between phase change temperature and constituent of binary systems NPG/PE and NPG/TAM

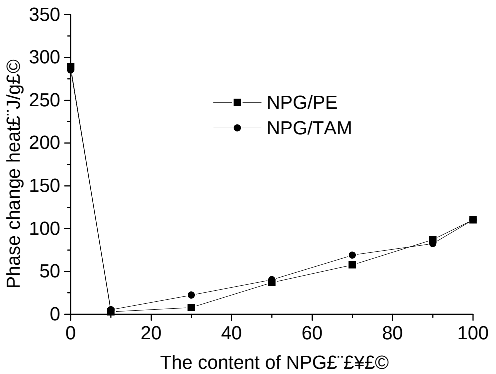

Fig. 2 The relationship between phase change latent heat and constituent of binary systems NPG/PE and NPG/TAM

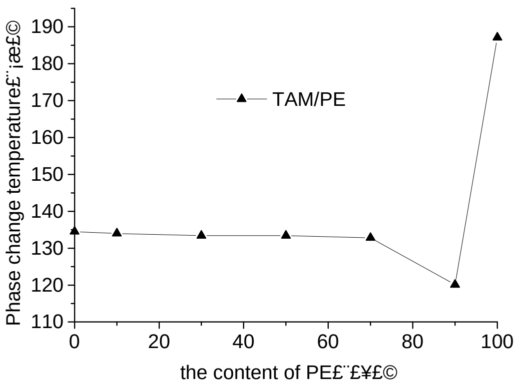

Fig. 3 The relationship between phase change temperature and constituent of binary system TAM/PE

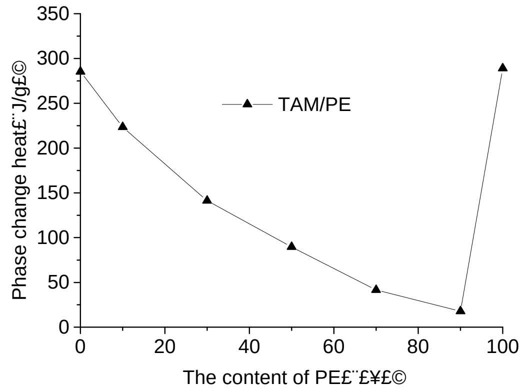

Fig. 4 The relationship between phase change latent heat and constituent of binary system TAM/PE

6. CONCLUSIONS

（1） The weightless rates of binary polyalcohols systems are lower and less than 5 percent in the solid-solid phase change process. The volatility of polyalcohols is related with the temperatures. The higher the temperature is, the larger the volatility. Polyalcohols binary systems had no weightless in the solid-solid phase change if polyalcohols were sealed.

（2） The method to prepare polyalcohols mixtures by heating and melting is not suitable because the constitution of polyalcohols mixture changes evidently with the temperature and time. Samples have not weightlessness if they are prepared by the method of melting and crystallization of dissolvent.

（3） The phase change temperatures of binary system NPG/PE and TAM/NPG are between 30 centigrade and 41 centigrade. The phase change heat of binary system is bigger when the content of NPG is 50 to 90 percent, and they can be used as thermal storage material. The phase change temperature of binary system PE/TAM is higher and about 130 , and the phase change heat is lower. Therefore, it is not significant to thermal storage.

（4） The binary polyalcohols systems with a certain constitution are ideal materials used in the building wall storage fields, but they should be sealed in the application.

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